

Evaluation of Waveguide Coating Materials

W. C. J. Chen and B. W. Baker

Radio Frequency and Microwave Subsystems Section

Waveguide coating materials were tested at 8470 MHz for insertion loss. Samples of these coatings on waveguide pieces without flanges were tested in an environmental chamber to simulate the effects of high power microwave heating.

I. Introduction

Stable high power handling is a requirement for some DSN tracking stations (Ref. 1). An improved X-band traveling wave resonant ring (Ref. 2) has been used in the past for high power tests and demonstrations. It was shown that stable (i.e., no arcing) CW high power could be obtained in the ring. However, copper waveguides without coating materials were used to construct the resonant ring, and no coating materials were evaluated at that time.

In a waveguide transmission system, surface finishes used for protection inside the waveguide play an important part in the value of attenuation measured. Cox and Rupp (Ref. 3) reported that good surface finish plus elimination of oxidation and corrosion are ways to minimize waveguide losses.

Acampora and Npioul (Ref. 4) studied the effects of surface roughness and particles on high power. They have observed that the presence of particles produces localized field enhancement and lowers the breakdown power.

This report covers three types of coating materials which were subjected to simulated high power and measured for insertion loss.

II. Experimental Method

Insertion loss measurements were initially made to determine if there were any significant differences between coating materials. The measurement technique was the DC potentiometer microwave insertion loss method developed by Stelzried, Reid and Petty (Ref. 5).

A 60.96 centimeters (2 feet) piece sample of WR 112 waveguide was coated with one of the three coating materials and the insertion loss of the piece was measured. After each measurement the waveguide was stripped, cleaned and recoated with a different material. The three coating materials were Metcot 7¹, BD-991² and Chemglaze R-104³.

A piece of clean waveguide without any coating and of the same length as the test samples was used as reference standard for calibration purposes.

The test input frequency was 8470 MHz. The experimental setup is shown in Fig. 1.

¹Metcot 7, product of Allied-Kelite, Des Plaines Illinois.

²BD-991, product of National Chemsearch, Irving, Texas.

³Chemglaze R-104, product of Hughson Chemicals, Lord Corp., Erie, Pennsylvania.

WR 90 waveguides in the environmental chamber test were arranged for high power simulation. Sample waveguides with Metcot 7, BD-991, Chemglaze R-104 and plain waveguide cleaned with nitric acid for 15 seconds were cycled between 300°F (148.8°C) and 70°F (21.1°C) temperature for one month, which simulated DSN operation of the high power transmitters. Five ounce nitrogen gas flowed in the test chamber at all times. This simulates the nitrogen circulating in the waveguide in a field installation.

III. Test Results

Each type of coating was measured consecutively 10 times. The standard plain waveguide was also measured 10 times for comparison. Results are shown as follows:

Waveguide samples	Average insertion loss, dB
Standard calibrated piece	0.04962
Metcot 7 coated	0.04727
BD-991 coated	0.04725
Chemglaze coated	0.04877

The plain waveguide without coating material has a rougher surface than the coated waveguide when examined with a microscope and the insertion loss is slightly higher than the coated guides, as expected. The insertion loss difference between the three types of coating is not considered significant.

The coated waveguides were examined by microscope before and after the environmental tests. The effects of the

RF heat simulation on the coated WR90 waveguides are summarized below and shown in Fig. 2.

Coated waveguide	Before test	After test
Metcot 7	Uniform coating surface, bright brown color	Coating surface nonuniformly distributed, color turns to deep brown gray; small peelings were observed
BD-991	Uniform coating distribution, bright brown color	Color turns to deep brown-gray; peelings were observed.
Chemglaze R-104	Uniform coating distribution, bright brown color	Coating still of uniform distribution, brown color; no peeling was observed.
Copper waveguide without coating, cleaned with nitric acid	Rough surface was observed, brown color	Color turns to dark gray; film was observed on the surface.

IV. Conclusion

Test results indicated that three types of coating materials are acceptable with regard to insertion loss. However, simulated microwave heating caused debonding of Metcot 7 and BD-991 coatings, resulting in peelings in the waveguide. The higher cost Chemglaze R104 does not exhibit this problem.

Acknowledgment

Vince Aneiro helped control the coating process.

References

1. Hartop, R., and Bathker, D. A. "The High-Power X-Band Planetary Radar at Goldstone: Design, Development, and Early Results," *IEEE Trans. Microwave Theory and Techniques*, Vol. MTT-24, No. 12, pp. 958-963, Dec. 1976.
2. Chen, W. C. J., and Hartop R., "Improved Cooling Design for High Power Waveguide System," *The Telecommunications and Data Acquisition Progress Report* 42-63, March and April 1981, pp. 104-107, Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1981.
3. Cox, R. M., and Rupp. W. E., "Fight Waveguide Losses 5 Ways," *Microwaves*, pp. 32-40, Aug. 1966.
4. Acampora, A. S., and Sproul, P. T., "Waveguide Breakdown Effects at High Average Power and Long Pulse Length," *The Bell System Technical Journal*, Vol. 51, No. 9, pp. 2065-2090, Nov. 1972.
5. Stelzried, C. T., Reid, M. S., and Petty, S. M., "A Precision DC Potentiometer Microwave Insertion Loss Test Set," *IEEE Trans. Instrumentation and Measurement*, Vol. IM-15 No. 3, pp. 98-106, Sept. 1966.



Fig. 1. Insertion loss measurement of sample X-band waveguide

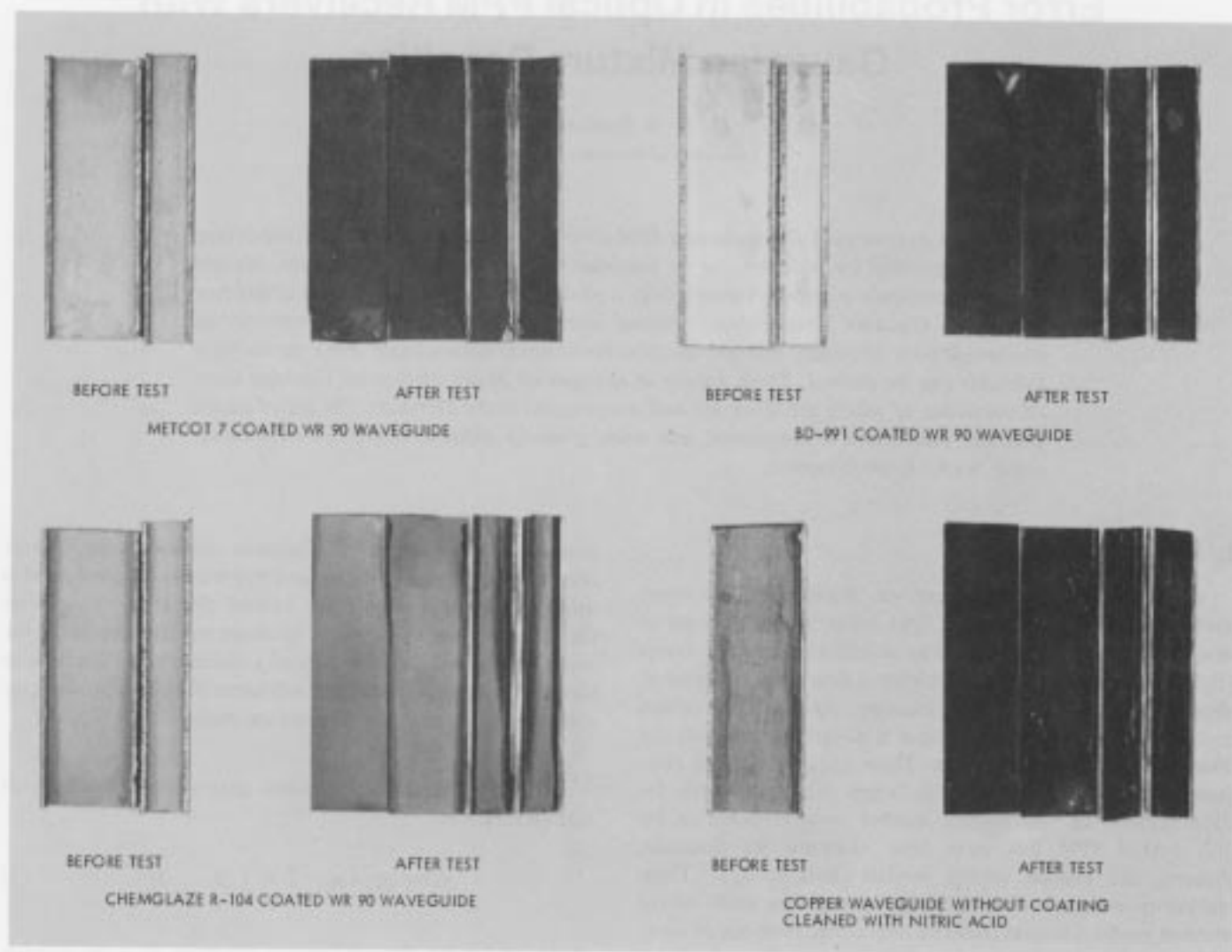


Fig. 2. Coated WR 90 waveguide samples before and after high power microwave heating simulation test